Constructional Project

Simple F.M. Radio

Raymond Haigh

Wide range tone controls and a 2W audio output make this an out-of-the-rut domestic receiver.

FOLLOWING the recent *Practical Radio Circuits* series (June '03 to Jan '04), a number of readers have requested a design for a simple v.h.f. f.m. receiver.

Three types of circuit meet the requirement for simplicity. The first two, super-regenerators and synchronous oscillators, were rejected because they can be difficult to set up and operate, and the lack of automatic frequency control causes problems in use.

The third utilizes the superhet principle, but adopts a simple resistance/capacitance coupled intermediate frequency amplifier instead of the conventional tuned circuit arrangement. The aerial input is broadly tuned to the f.m. band, and only the oscillator has a variably tuned circuit. This greatly simplifies the construction and setting up of the chosen Simple F.M. Radio design described here.

A Good Combination

Readers will, no doubt, have their own ideas about audio amplifiers, speakers and cabinet size, so the F.M. Tuner section is assembled on a separate printed circuit board (p.c.b.). It can be combined with simple amplifiers – such as those described in the *Simple Audio Circuits* (May '02 to Aug '02) series or the radio series mentioned at the start – to form a small portable, or it can be teamed with more ambitious audio stages to produce an out-of-the-rut domestic receiver.

The latter approach has been adopted here, and details of a wide range tone control unit, a "robust" audio amplifier, and a mains power supply are included.

Radio Chip

The internal structure, in block form, of the TDA7000 f.m. radio i.c. is shown in Fig.1.

Signals picked up by the aerial are combined with locally generated oscillations in the mixer stage. The resulting intermediate frequency (i.f.) is amplified by two filter amplifiers and a limiter amplifier. Together with external capacitors, the filter amplifiers centre the intermediate frequency around 70kHz. The limiter amplifier provides automatic gain control (a.g.c.) and suppresses amplitude modulated (a.m.) signals.

Because of the low intermediate frequency, the deviation produced by signals that are heavily modulated must be restricted to around plus/minus 15kHz. This is achieved by feeding the output from the demodulator back to the local oscillator (via the loop filter) and using it as a control voltage to shift the oscillator frequency in the opposite direction to the i.f. deviation. The oscillator stage incorporates on-chip tuning diodes to enable this and other control voltages to shift its operating frequency.

The correlator and muting sections suppress image responses that would otherwise be an irritating problem with the low intermediate frequency. (Stations would tune-in at two points on the dial.) This complex circuitry, made possible by the large-scale integration of components, sets the design apart from earlier valve versions.

The muting circuits result in a complete absence of noise when tuning between stations. Searching for zero hiss is, however, the customary way of locating a station and precisely tuning the receiver to it. To give radios using the chip a conventional "feel", Philips included a noise source that simulates the inter-station hiss.

Demodulation is by means of a quadrature detector which requires the production of a 90 degree phase-shift in the signal (hence quadrature). Again, this is complex circuitry that can only be realized, in practice, by the large-scale integration of resistors and semiconductors.

A stage of audio amplification is included on the chip, and the output is approximately 75mV r.m.s.

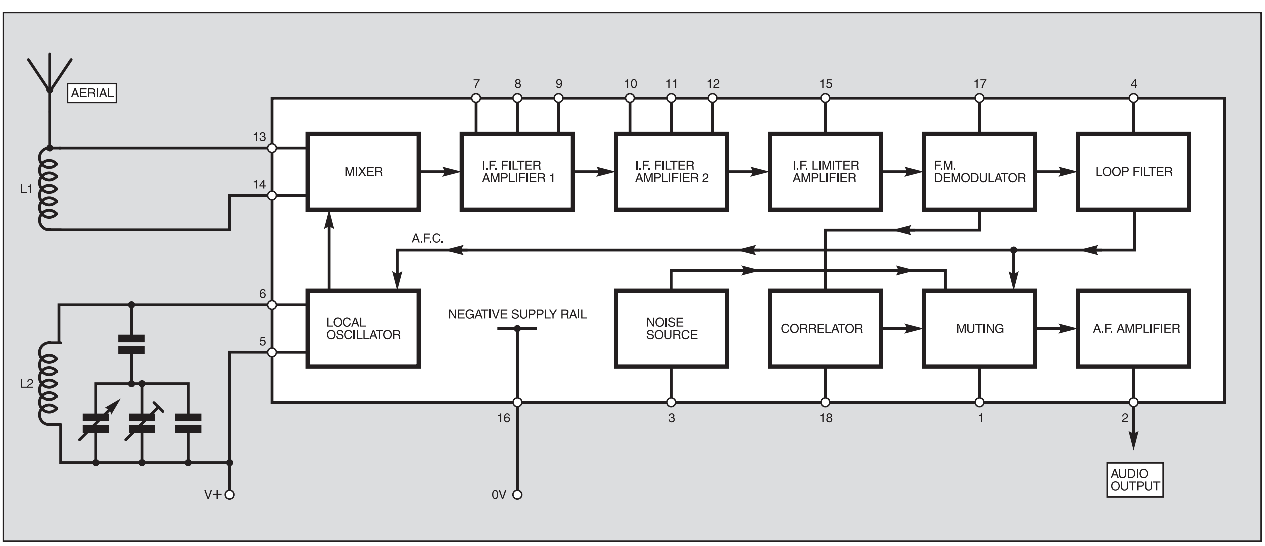


Fig.1. Block diagram showing the internal arrangement of the Phillips TDA7000 f.m. radio integrated circuit.

F.M. Tuner

The full circuit diagram of the F.M. Tuner section of the receiver is shown in Fig.2. On-chip bias resistors damp the input circuit so heavily that variable tuning is pointless. Accordingly, the aerial coil is broadly tuned by self and stray capacitance to the v.h.f. f.m. band. The circuit is isolated from low level, low frequency a.c. and d.c. inputs by capacitor C1, and the "earthy" end of L1 is grounded by C2.

The oscillator stage is tuned by coil L2 and variable capacitor VC1. An integral trimmer capacitor, VC2, adjusts the minimum capacitance in circuit and sets the upper frequency limit coverage.

The combination of fixed series capacitor C11 and parallel capacitor C13 modify the effect of tuning capacitor VC1 and spread the 88MHz to 108MHz band over its entire swing. This makes tuning the receiver much easier.

Constructors should note that the on-chip oscillator circuit calls for the moving vanes (spindle) of the tuning capacitor, VC1, to be connected to the positive supply rail. The tuning capacitor spindle ***must***, therefore, be *insulated* from any grounded metal front panel or case.

Filter Amplifiers

Capacitors C6 and C15, together with on-chip resistors, set the cut-off frequency of the first, low-pass, filter. The bandpass response of the second filter is set by C8, C9 and C12 (see Fig.1 and Fig.2).

Two capacitors, C3 and C4, are combined to produce a difficult-to-obtain value for the component that determines the time constant of the muting circuit.

The time constant of the internal feedback loop is set by C7. This capacitor influences the willingness of the receiver to lock onto weak signals and thereby affects sensitivity. Too low a value makes the circuit reluctant to lock; too high a value reduces response to the upper audio frequencies.

The value suggested by the manufacturers is 10nF, but a higher value will improve performance in areas where signals are not strong. A 68nF component is fitted in the prototype receiver as this seems to give the best overall results. The barely perceptible reduction in treble response is made good by reducing the value of the audio de-emphasis capacitor C19, and the tone control circuit described later.

Smooth Output

Supply line decoupling is provided at radio frequencies by capacitor C10, and at audio frequencies by resistor R2 and capacitor C18. Decoupling capacitor C21 inhibits radiation of the oscillator signal by the battery or power supply wiring.

Inter-station noise is set by capacitor C5. Increase the value of this capacitor to make the hiss louder; delete it for completely silent tuning. Audio output is developed across resistor R1, and C19 provides audio de-emphasis.

Coils

Details of the self-supporting coils and the connections to typical polyvarycon (polythene) tuning capacitors are given in Fig.3.

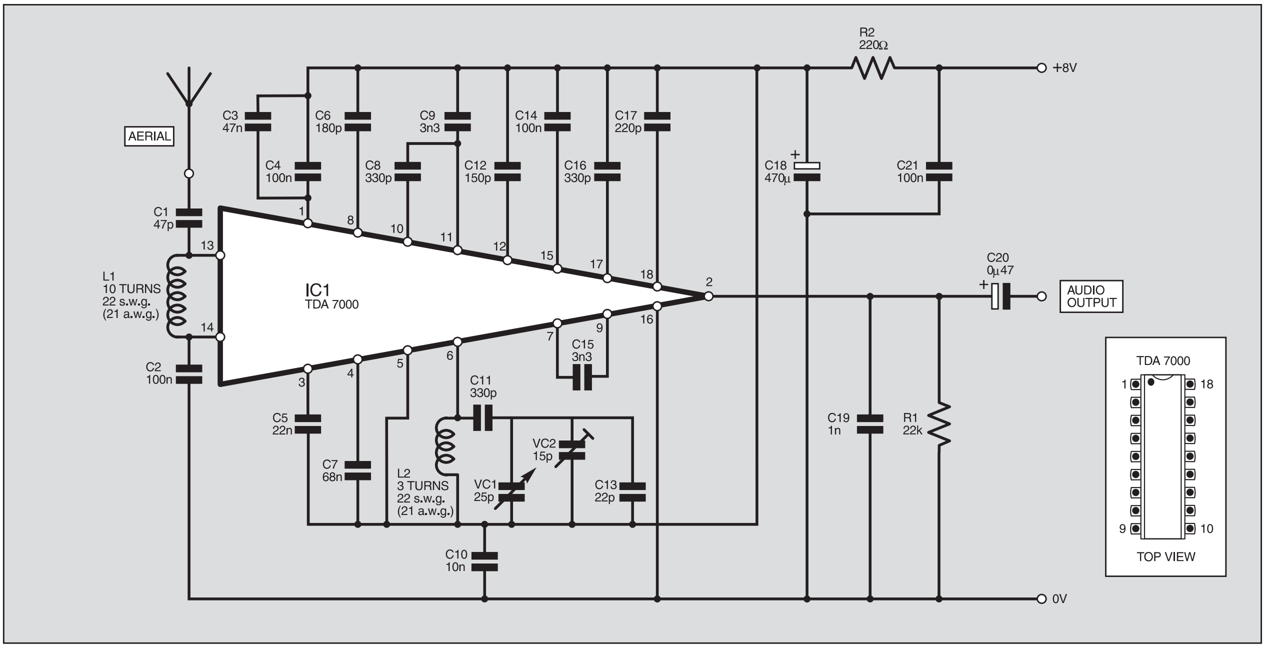


Fig.2. Complete circuit diagram for the F.M. Tuner section of the Simple F.M. Radio.

History

Some of the first superhet receivers, produced during the early 1920s, had resistance/capacitance coupled i.f. (intermediate frequency) stages. The absence of tuned circuits meant that the i.f. amplifier made no contribution to the selectivity of the receiver, and the practice was soon abandoned.

Frequency modulation broadcasting (f.m.) was established in the 1950s. This system requires the i.f. amplifier to have a wide response; i.e. to lack selectivity. Resistance/capacitance coupled i.f. stages could, therefore, be used, and valve circuits of this kind reappeared to meet a demand for simple and inexpensive receivers.

The concept was resurrected again by Philips in the late 70s when they were attempting to form an f.m. receiver on a single chip. The outcome was the TDA7000 integrated circuit, which is still widely available. Ingenious circuitry, made possible by combining many resistors and transistors on a tiny wafer of silicon, overcome the drawbacks of earlier valve designs.

Form the coils by tightly winding 22s.w.g. (21a.w.g.) enamelled copper wire onto a length of 6mm (1/4in) potentiometer spindle. It is a good idea to bend the ends and scrape them "bright-metal-clean" of enamel before removing the winding from the spindle.

The aerial input coil L1 is not at all critical, but the oscillator coil L2 should be carefully spaced, as shown in the illustration.

COMPONENTS

F.M. TUNER

See SHOP TALK page

Resistors

R1	22k
R2	220Ω

All 0·25W 5% carbon film

Capacitors

C1	47p ceramic
C2, C4, C14, C21	100n ceramic (4 off)
C3	47n ceramic
C5	22n ceramic
C6	180p ceramic
C7	68n ceramic (see text)
C8, C11, C16	330p ceramic (3 off)
C9, C15	3n3 ceramic (2 off)
C10	10n ceramic
C12	150p ceramic
C13	22p "low k" ceramic
C17	220p ceramic
C18	470µ radial elect. 25V
C19	1n ceramic
C20	0µ47 radial elect. 25V (preferred) or polyester film
VC1, VC2	miniature a.m./f.m. polythene dielectric tuning capacitor, with integral trimmers (only one f.m. section – 25pF – and one trimmer –15pF – used)

Semiconductors

IC1	TDA7000 f.m. radio i.c. (Philips)

Miscellaneous

L1, L2	coils hand-wound with 22s.w.g. (21a.w.g.) enamelled copper wire – see text and Fig.3 for winding details

Printed circuit board available from the *EPE PCB Service*, code 458; 18-pin d.i.l. socket; 50g (2oz) reel 22s.w.g. (21a.w.g.) enamelled copper wire for coils; spindle extender for variable capacitor and/or spindle coupler (see text), and slow motion drive (optional); large control knob; telescopic whip aerial (see text); multistrand connecting wire; solder pins; mounting nuts, bolts and washers; p.c.b. stand-offs; pillars; solder etc.

CABINET

Medium density fibreboard (mdf), 12·5mm thick; glue and moulding pins; filler and car spray paint; speaker and rear vent grilles; speaker fixing screws; carrying handle; back fixing screws and rubber feet (4 off); materials for front panel.

Approx. Cost Guidance Only £15 *excl. cabinet materials*

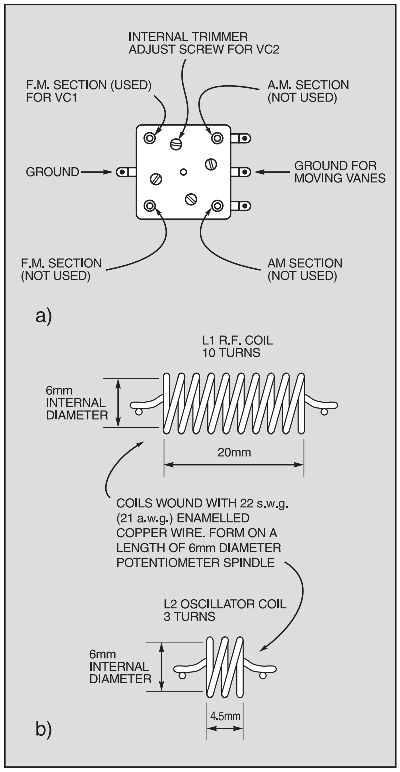


Fig.3. Tuning capacitor connections and coil winding details. Connections are typical of most polythene dielectric variable capacitors – but check.

Tuner Construction

Apart from the telescopic "whip" aerial, all the components for the F.M. Tuner are mounted on a small single-sided printed circuit board (p.c.b.). The topside component layout, full-size copper track master and wiring details are shown in Fig.4. This board is available from the *EPE PCB Service*, code 458.

You should use an i.c. holder for the TDA7000 integrated circuit as this will make it easy for any substitution and checking purposes. Mount the d.i.l. holder on the board first. Solder pins will ease the task of off-board wiring, and these should be inserted into the board next. Follow with the coils, L1 and L2, inserting them until the windings almost touch the surface of the board.

The two resistors can be fitted now, then the capacitors, smallest first. Mount the tuning capacitor VC1 last. Take care to orientate this component correctly to ensure that an f.m. tuning section is connected into circuit.

If an a.m. section is inadvertently connected, tuning will be abrupt and the band will be confined to only part of its swing. It may be necessary to countersink the tuning capacitor spindle hole, on the component side of the board, to ensure that the capacitor seats properly.

Check the completed p.c.b. for poor soldered joints and bridged tracks. Double-check also component placement and particularly the orientation of the electrolytic

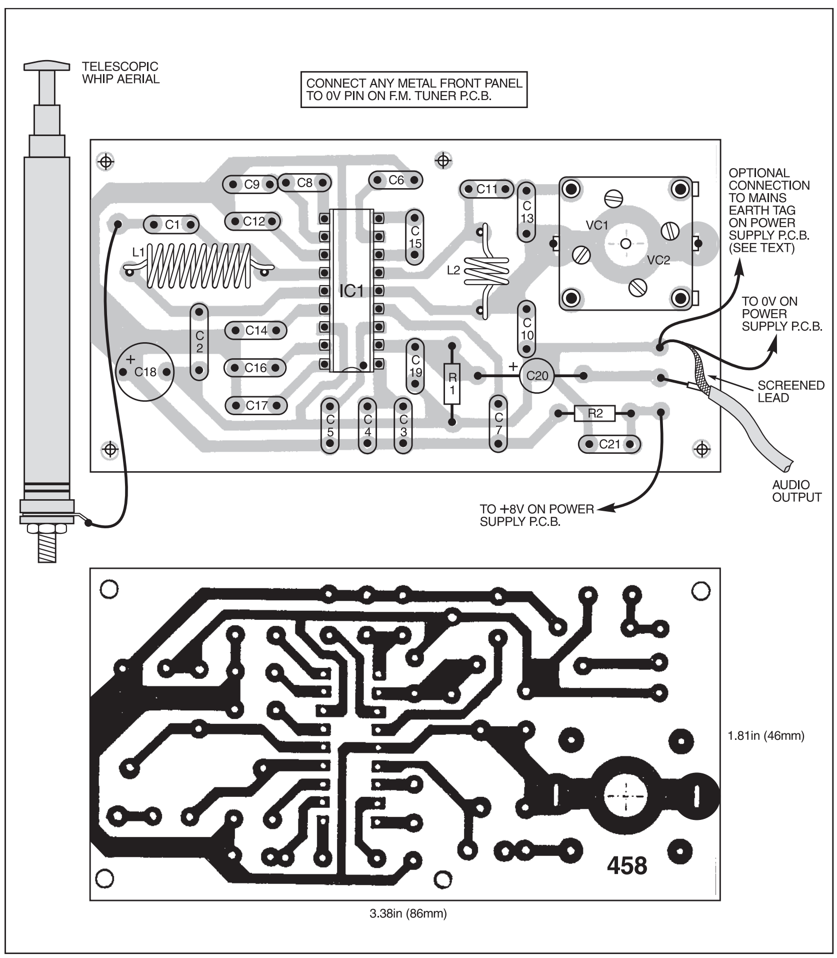


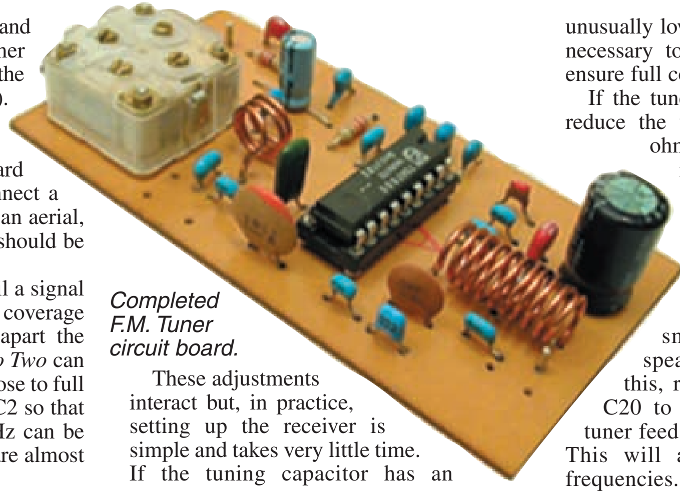
Fig.4. F.M. Tuner printed circuit board component layout, wiring details and full-size copper foil master pattern.

capacitors, the integrated circuit and the tuning capacitor. Set trimmer capacitor, VC2, at half mesh (the vanes can be seen through the case).

Tuning In

Connect the finished Tuner board to an amplifier and speaker. Connect a couple of metres of flex to act as an aerial, and connect a 9V battery. A hiss should be heard from the speaker.

Rotate the tuning capacitor until a signal is received. Set the low frequency coverage by *gently* squeezing or pulling apart the oscillator coil L2 until *BBC Radio Two* can be heard with the vanes of VC1 close to full mesh (closed). Adjust trimmer VC2 so that any local station close to 108MHz can be received when the vanes of VC1 are almost fully open.



Completed F.M. Tuner circuit board.

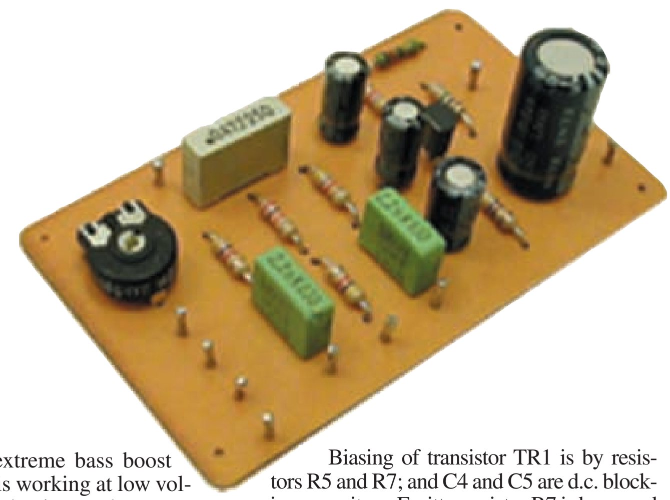
These adjustments interact but, in practice, setting up the receiver is simple and takes very little time.

If the tuning capacitor has an unusually low value (not likely), it may be necessary to short out capacitor C11 to ensure full coverage of the band.

If the tuner is used with a 6V battery, reduce the value of resistor R2 to 100 ohms. If low frequency instability is encountered when the value of R2 is reduced (not likely), increase the value of C18 to 1000μF.

The tuner's extended bass response can cause severe overloading when small audio amplifiers and speakers are used. To prevent this, reduce the value of capacitor C20 to 100nF or even 47nF if the tuner feeds into a high impedance load. This will attenuate the lowest audio frequencies.

Add-On Audio Circuits



A PORTABLE receiver with a powerful output and an extended bass response can make listening to music more pleasurable. With this in mind, a Tone Control unit, Audio Power Amplifier and Power Supply are detailed next. Assembling these units on individual printed circuit boards permits maximum flexibility in laying out the F.M. Radio.

A larger speaker is needed to deliver the extended low frequency bass response, but the increase in cabinet size need not be excessive, and it will permit the installation of a decent whip aerial.

Tone Control

First published by P. J. Baxandall fifty years ago, the Tone Control circuit illustrated in Fig.5 is found, with variations, in most high fidelity amplifiers. All tone control circuits produce "boost" in one region of the audio spectrum by reducing response at all others. This arrangement uses gain reducing negative feedback to achieve the desired result.

Potentiometers VR2 and VR3, and capacitors C1, C2 and C3, form a frequency selective network that controls the feedback from the collector (c) to the base (b) of transistor TR1. Interaction between Bass control VR2 and Treble control VR3 is limited by resistors R2 and R3.

Increasing the value of the F.M. Tuner's loop lock capacitor (C7 on the Tuner p.c.b.) makes the audio output a little bass heavy. When this is augmented by the tone control circuit, the result is more bass than most reasonably sized speakers and amplifiers can handle when delivering a good level of sound.

Bass control VR2 can, of course, be turned back to avoid overloading, but a better arrangement is to make provision for switching in the extreme bass boost when the receiver is working at low volume. Sound reproduction at low outputs can lack presence, and the bass emphasis will help to overcome this.

Preset VR1, connected in series with one arm of Bass control VR2, enables the bass boost to be set below the overload point when the receiver is used at high volume. Switch S1 shorts out the preset and allows the bass boost to rise to its maximum level for quiet listening.

Biasing of transistor TR1 is by resistors R5 and R7; and C4 and C5 are d.c. blocking capacitors. Emitter resistor R7 is bypassed by C6. Audio output is developed across collector load resistor R6 and the stage is decoupled from the supply rail by R8 and C7.

A d.c. blocking capacitor for the output signal path is provided on the power amplifier printed circuit board. Readers wishing to use this circuit with other equipment should take the output from the collector of TR1 via a 4·7μF capacitor.

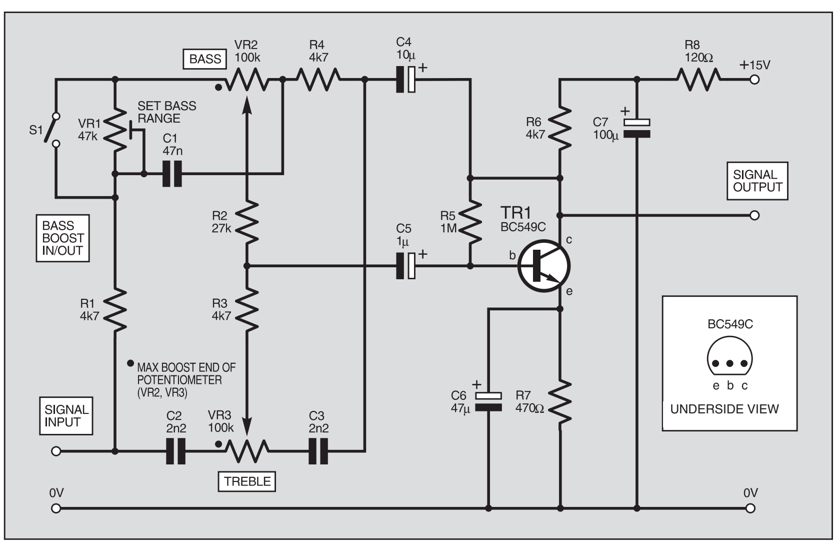


Fig.5. Circuit diagram for an add-on Tone Control Unit.

Power Amplifier

The circuit of the Audio Power Amplifier is given in Fig.6. Designed around SGS Thomson's TDA2003 i.c., the circuit will deliver a clean 2W into an 8 ohm speaker when connected to a 15V power supply.

The signal input from the Tone Control circuit is applied via Volume control potentiometer VR1 and d.c. blocking capacitor C1. A second blocking capacitor, C2, must be provided to prevent disturbance of a bias voltage on the input pin (1) of IC1.

Supply decoupling capacitors, C3 and C4, ensure stability at low and high frequencies, and the gain of the circuit is determined by resistors R2 and R3, which fix the level of negative feedback. The value of R3 has been reduced from its more usual 2·2 ohms to increase gain.

In the interests of stability, the high frequency response of the amplifier is rolled off above 15kHz by the combination of resistor R1 and capacitor C5. The output signal is coupled to the speakers by d.c. blocking capacitor C7. Zobel network R4 and C8 ensures that the speakers always present a resistive load to the amplifier. Without these components, high level transients could damage the internal output transistors of IC1.

Speakers

Generating a decent low frequency output from a modest electrical input calls for a speaker of reasonable diameter. To get the best out of the receiver, the Bass speaker should be at least 200mm (8in) in diameter. Reproducing deep bass will involve fairly large cone excursions, and it should, if possible, have a foam surround. Units of this kind are available at modest cost.

A "tweeter" or Treble speaker will add brilliance to the reproduction, and a moving coil unit is suitable. It should be connected across the bass speaker via a 10μF bipolar electrolytic capacitor (C9 in Fig.6).

Power Amplifier p.c.b. A heatsink will be required for the i.c.

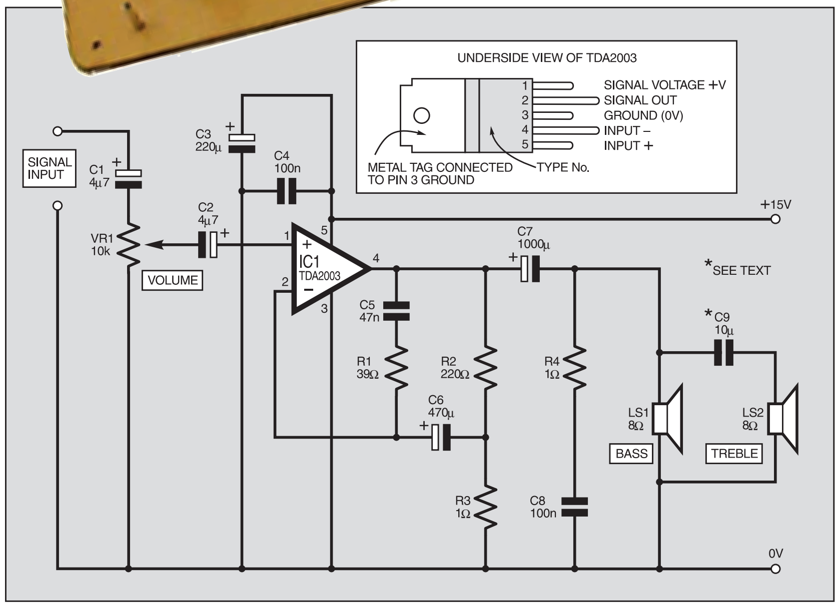
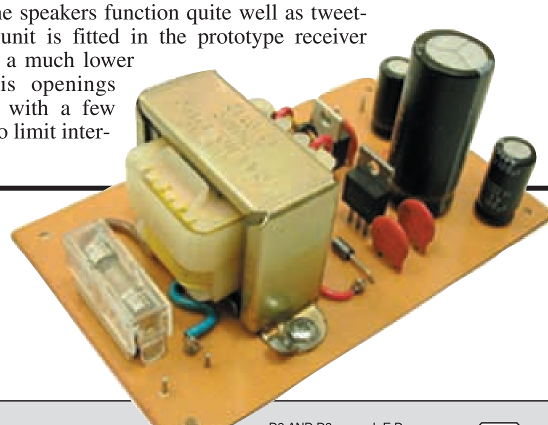


Fig.6. Circuit diagram for the Audio Power Amplifier.

Inexpensive Mylar cone speakers function quite well as tweeters, and a 75mm (3in) unit is fitted in the prototype receiver (smaller units tested had a much lower output). Tweeter chassis openings should be covered over with a few layers of insulating tape to limit interaction with the bass unit.



Mains Power Supply Unit

It is not feasible to power a receiver as potent as this from dry batteries, and a mains power unit should be regarded as essential. ***Readers who have no experience of mains-powered equipment should remember that the voltages involved are LETHAL.***

If there is the least doubt about your ability to build and commission a mains unit, ***you must*** either seek assistance from an experienced constructor or combine the tuner with a smaller amplifier that can be powered by batteries.

Circuit Details

The circuit diagram for the Mains Power Supply Unit (p.s.u.) is given in Fig.7. A bi-phase full-wave rectifier circuit has been adopted, and this calls for a centre-tapped mains transformer, T1. Low value fuse, FS1, increases the safety of the equipment.

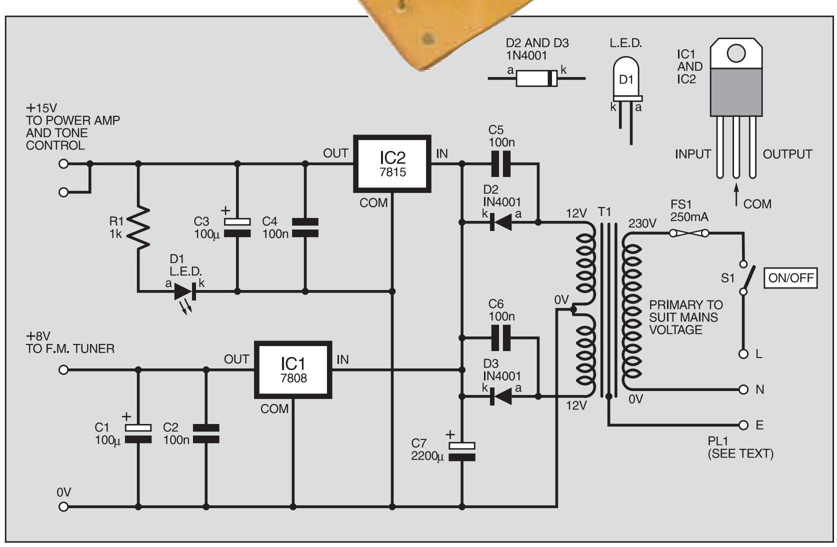


Fig.7. Circuit diagram for the Mains Power Supply Unit.

The switching action of rectifier diodes D2 and D3 can modulate radio frequency currents picked up by the mains wiring. The resulting signal manifests itself as a tunable hum in receivers connected to the power supply. However, including shunt capacitors C5 and C6 prevents this interference arising.

Reservoir capacitor C7 smoothes the output from the rectifiers and enables the d.c. voltage to approach its peak value when current drain is low. With a 12V transformer, the supply rail can have a potential of more than 18V. This exceeds the maximum working voltage for the power amplifier, and greatly exceeds the voltage required for the tuner.

Regulators IC1 and IC2 deliver the appropriate 8V and 15V outputs for the tuner and amplifier. These devices produce low-level wideband electrical noise, and this is bypassed by capacitor combinations C1/C2 and C3/C4.

Light emitting diode D1, powered via its dropping resistor R1, acts as a power-on indicator. On/Off pushswitch (or toggle switch) S1 is connected in the Live lead of the mains supply. Mains Earth is connected to the frame and core of mains transformer T1. It is recommended that a standard three-pin mains-input Euro plug be mounted in the cabinet.

COMPONENTS

TONE CONTROL

Resistors
R1, R3,
R4, R6 4k7 (4 off)
R2 27k
R5 1M
R7 470Ω
R8 120Ω
All 0·25W 5% carbon film

See SHOP TALK page

Potentiometers
VR1 47k enclosed carbon preset
VR2, VR3 100k rotary carbon, lin. (2 off)

Capacitors
C1 47n polyester film
C2,C3 2n2 polyester film (2 off)
C4 10μ radial elect. 25V
C5 1μ radial elect. 25V
C6 47μ radial elect. 25V
C7 100μ radial elect. 25V

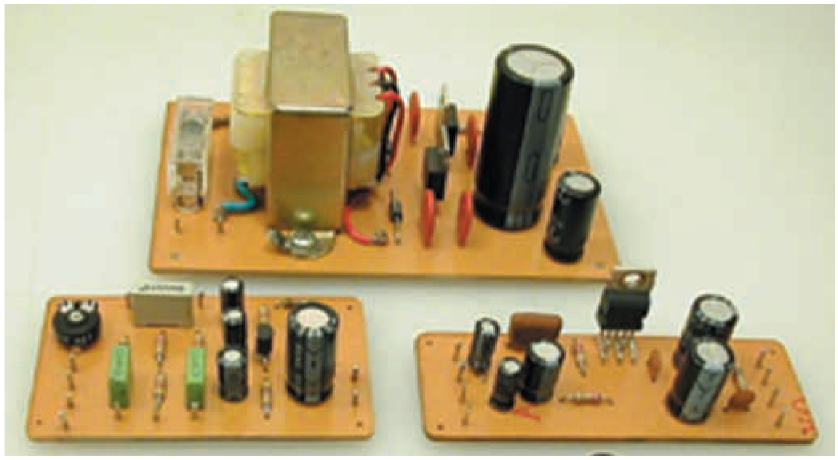
Semiconductors
TR1 BC549C *npn* low power transistor or similar

Miscellaneous
S1 pushbutton locking switch, push-to-make, or s.p.s.t. toggle switch

Printed circuit board available from *EPE PCB Service*, code 459; audio screened cable; small plastic control knob (2 off); multistrand connecting wire; mounting nuts, and washers; p.c.b. stand-off pillars (4 off); solder pins; solder etc.

Approx. Cost Guidance Only **£10** *excl.*

CONSTRUCTION – TONE CONTROL ● POWER AMP ● PSU



Final Assembly

The Tone Control Unit, Audio Power Amplifier and Power Supply Unit are assembled on individual printed circuit boards (p.c.b.s).

The board for the Tone Control, together with the connections to the Bass and Treble potentiometers, is shown in Fig.8, together with the full-size copper track master. This board is available from the *EPE PCB Service*, code 459.

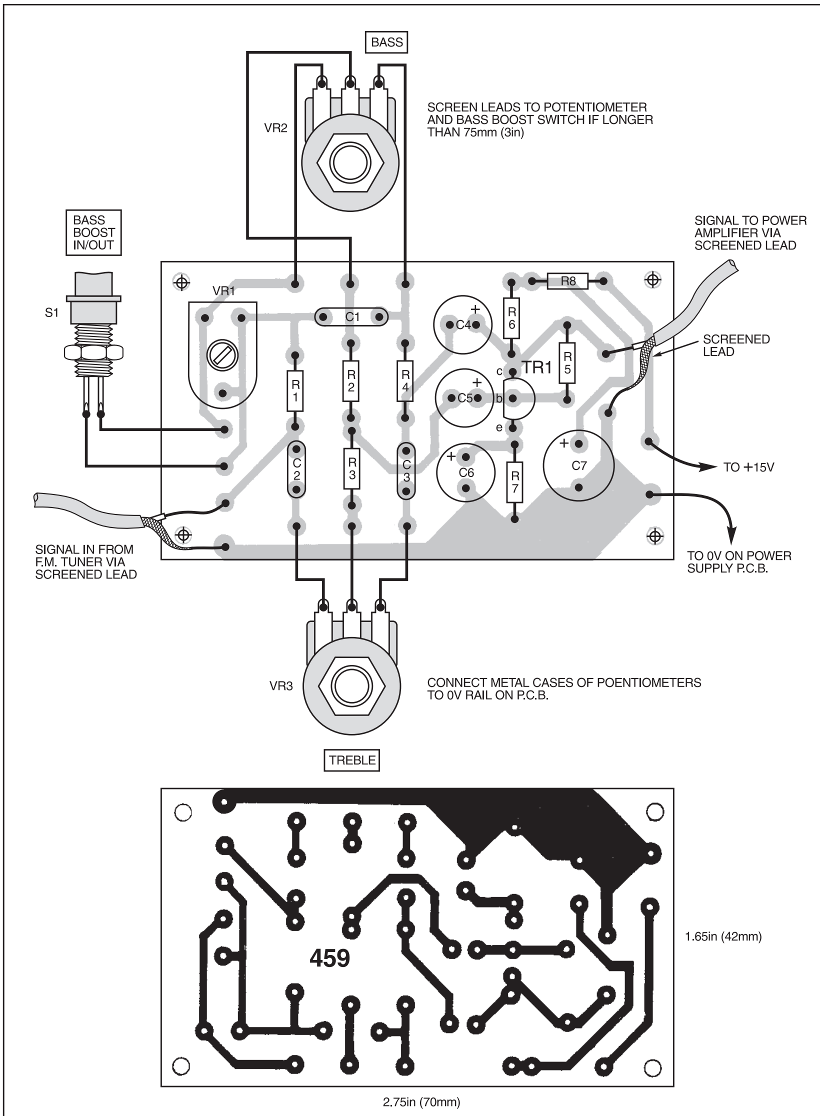


Fig.8. Printed circuit board component layout, wiring details and full-size copper foil master for the add-on Tone Control.

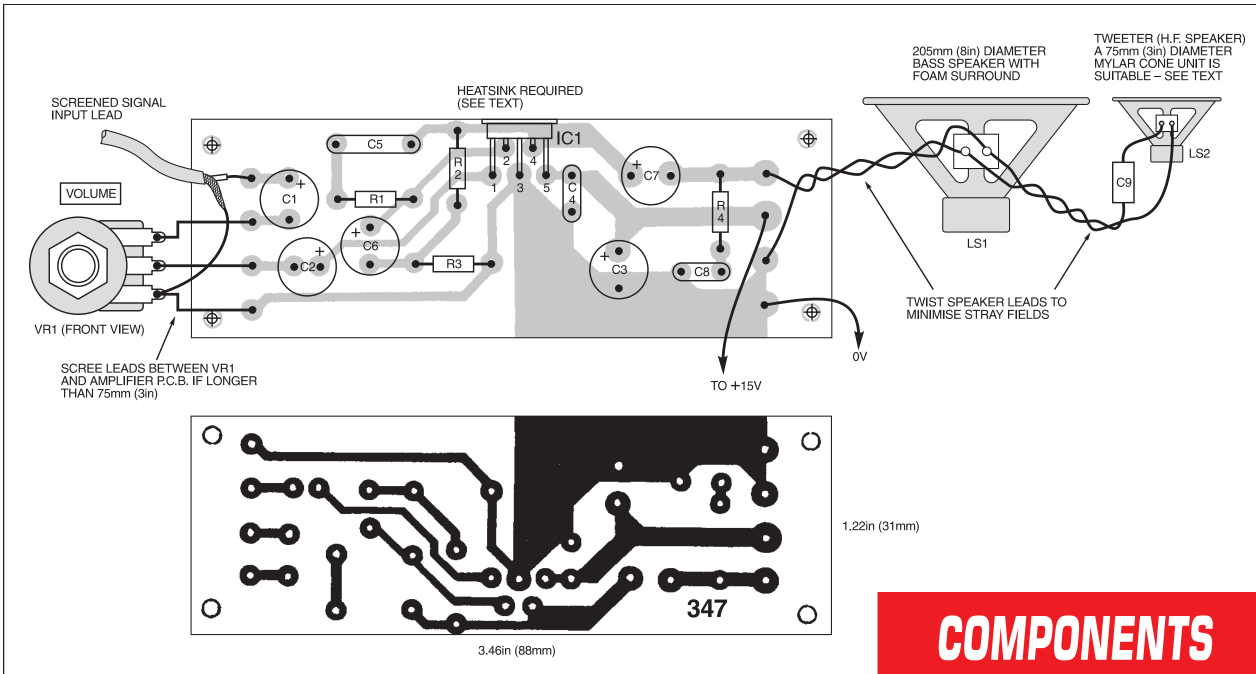


Fig.9. Audio Power Amplifier printed circuit board component layout, full-size underside copper foil master and interwiring details from the p.c.b. to the Volume control and speakers. Note, the bipolar electrolytic capacitor (C9) is mounted directly on the Bass speaker terminals.

The component side of the TDA2003 Power Amplifier printed circuit board, full-size underside copper foil master and wiring to the Volume control and the two speakers are illustrated in Fig.9. (This board is also available from the *EPE PCB Service* and is the same one from the *Audio Circuits* series, code 347.)

The component side of the Power Supply p.c.b., full-size copper foil master pattern and wiring details to off-board components are shown in Fig.10. This board is available from the *EPE PCB Service*, code 460.

As before, solder pins, inserted at the lead-out points, will simplify inter-board wiring. They should be inserted first, followed by the resistors, then the capacitors, beginning with the smallest. Semiconductors should be soldered in place last.

The mains transformer is bolted to the power supply board and its frame is isolated from the 0V rail. Place a solder tag beneath one of the fixings for the mains earth connection.

On completion, check the boards thoroughly for poor soldered joints or bridged tracks. Check the placement of components and the orientation of semiconductors and electrolytic capacitors.

A Hot Point

The TDA2003 amplifier (IC1) is internally protected and will shut down if its temperature rises excessively, or if its output is short circuited. Heat sinking is essential for the proper operation of this device.

Bolt the metal tag on the audio amplifier i.c. to a piece of 16s.w.g. aluminium at least 50mm × 50mm (2in × 2in) or a commercial heatsink of equivalent area. In the prototype receiver, the bracket that attaches the amplifier to the front panel acts as the heatsink.

Power supply regulators, IC1 and IC2, will function without heatsinks. Current drawn via the 8V regulator is quite low (8mA), and the minimal (2·5V) voltage drop across the 15V regulator keeps dissipation within the device at a modest level.

Miniature mains transformers tend to run quite warm, even when lightly loaded. The receiver case must, therefore, be adequately ventilated to keep the temperature rise of this component within acceptable limits.

Connect the power supply unit to the mains and check the output voltages before wiring it into the receiver. **Extreme care must be taken when building the Mains PSU as lethal mains voltages are, of course, present. It should only be put together by an experienced constructor.**

Interwiring

Screened audio cable should be used for all signal leads longer than 75mm (3in). If a non-metallic front panel is used, remember to connect the metal cases of potentiometers and switches to the 0V rail (ground).

Similarly, any metal front panel should be connected to the 0V rail. Constructors are reminded that the spindle of the tuning capacitor is connected to supply positive, and it must be insulated if it passes through a metal front panel.

Do not rely on screened cable braiding to carry the 0V rail to the printed circuit boards. A separate connection must be made, from the designated point on each board, to the 0V pin on the power supply.

At f.m. band frequencies, the mains wiring will sometimes act as one half of a dipole aerial (the whip aerial is, of course, the other) and increase signal pick-up. Situations vary, and a temporary connection should be made between the mains earth solder tag at transformer T1 and the 0V pin on the tuner board. Make the test with the receiver tuned to a "difficult" station. If the arrangement improves reception, a permanent connection can be made.

COMPONENTS

AUDIO POWER AMPLIFIER

Resistors

R1	39Ω
R2	220Ω
R3, R4	1Ω (2 off)

All 0·25W 5% carbon film

See SHOP TALK page

Potentiometer

VR1	10k rotary carbon, log.

Capacitors

C1, C2	4µ7 radial elect. 25V (2 off)
C3	220µ radial elect. 25V (2 off)
C4, C8	100n ceramic (2 off)
C5	47n ceramic
C6	470µ radial elect. 25V
C7	1000µ radial elect. 25V
C9	10µ bipolar elect. 25V (or wire two 22µ 25V standard electrolytics in series – negative connected to negative)

Semiconductors.

IC1	TDA2003 audio power amp. i.c. (SGS Thomson)

Miscellaneous

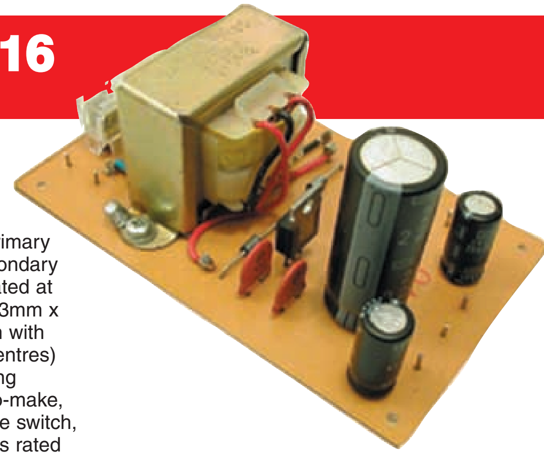
LS1	8 ohm 205mm (8in) diameter, foam surround, loudspeaker – see text
LS2	8 ohm 76mm (3in) diameter, mylar cone, loudspeaker, or "tweeter" unit (optional)

Printed circuit board available from *EPE PCB Service*, code 347; audio screened cable; piece of 16s.w.g. aluminium, 50mm (2in) x 50mm (22in), for heatsink (see text); small control knob; multistrand connecting wire; mounting nuts, bolts and washers; p.c.b. stand-off pillars (4 off); solder pins; solder etc.

Approx. Cost Guidance Only **£10** ***excl. speakers***

COMPONENTS

Approx. Cost Guidance Only excl. mains plug & cable **£16**



POWER SUPPLY

See SHOP TALK page

Resistors

R1	1k 0·25W 5% carbon film

Capacitors

C1, C3	100µ radial elect. 25V (2 off)
C2, C4	100n ceramic (2 off)
C5, C6	100n ceramic, 50V (2 off)
C7	2200µ radial elect. 25V

Semiconductors

D1	5mm red l.e.d.
D2, D3,	1N4001 50V 1A rect. diode (2 off)
IC1	7808 8V 1A voltage regulator
IC2	7815 15V 1A voltage regulator

Miscellaneous

T1	miniature mains transformer: primary 230V a.c.; secondary 12V-0V-12V, rated at 250mA (size 43mm x 35mm x 36mm with 51mm fixing centres)
S1	pushbutton locking switch, push-to-make, or s.p.s.t. toggle switch, both with mains rated contacts
PL1	3-pin Eurostyle mains inlet plug
FS1	250mA 20mm fuse, with p.c.b. mounting fuseholder and protective cover

Printed circuit board available from the *EPE PCB Service*, code 460; l.e.d. holder; solder tag for Earth connection; mains cable; multistrand connecting wire; mounting nuts, bolts and washers; p.c.b. standoffs; pillars (4 off); solder pins, solder etc.

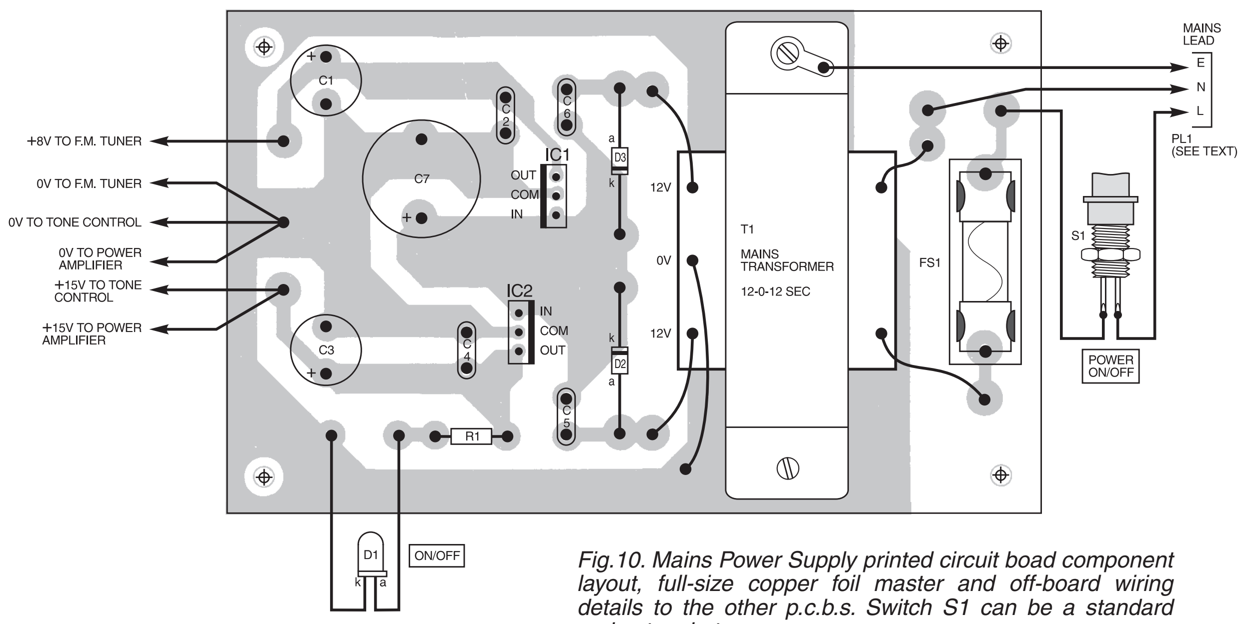
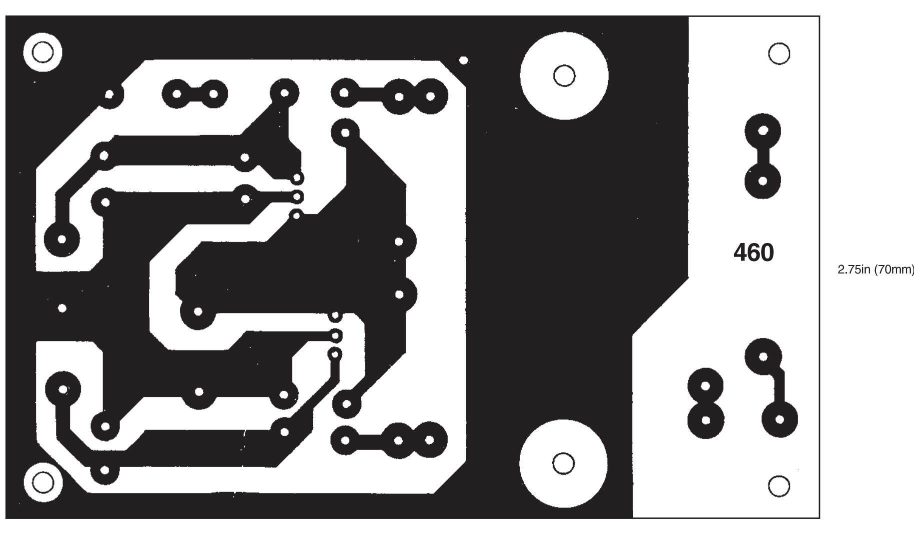
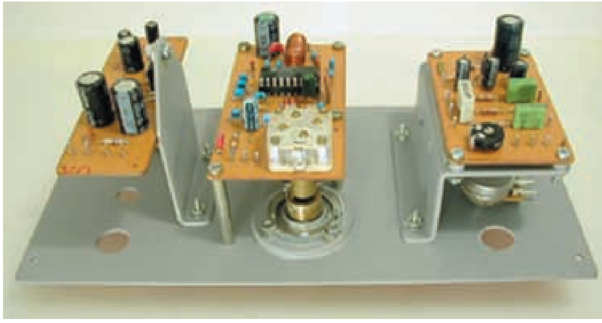


Fig.10. Mains Power Supply printed circuit boad component layout, full-size copper foil master and off-board wiring details to the other p.c.b.s. Switch S1 can be a standard mains toggle type.





The Power Amp, Tuner and Tone Control p.c.b.s mounted on spacers and brackets behind the radio front panel. Note the Power Amp bracket acts as a heatsink for the amplifier i.c.

Front panel control layout for the F.M. Radio.

Set Building

Tuner, Tone Control and Power Amplifier printed circuit boards are all mounted behind a front panel that carries all of the controls. A 205mm × 105mm (8in × 4in) piece of double-sided fibre glass printed circuit board forms the panel in the prototype receiver, but a piece of 16s.w.g. aluminium would do just as well.

Mounting the boards on long stand-offs holds them above the associated potentiometers and the inter-connecting leads can then be kept short.

The power supply is mounted on the side of the cabinet, and the entire arrangement is depicted in the various photographs. Note that for safety reasons no metal fixings for the power supply p.c.b. must be allowed to pass through the cabinet – use nylon bolts or short wood screws to fix the p.c.b.

Dial-up

In the prototype radio, an epicyclic slow-motion drive is fitted to the tuning capacitor. This is not essential, but it does make the receiver more pleasant to operate. The polythene dielectric (polyvaricon) type tuning capacitor spindles are short, so a spindle coupler and short length of plastic potentiometer spindle may still be needed to connect capacitor to drive. The plastic spindle insulates the tuning capacitor (see earlier).

The Bass speaker and p.c.b.s mounted inside the wooden case. The h.f. speaker is glued to the back of the speaker grille.

The prototype front panel is annotated with rub-down lettering applied to white card and protected by a piece of 2mm thick acrylic sheet (the kind of material used for DIY double glazing). A pointer for the dial is made from scrap acrylic sheet.

Cabinet

Cabinet size is determined by speaker size, and the prototype is just wide enough, internally, to accommodate the 205mm diameter (8in) speaker. Constructed from 12·5mm ($^{1}/_{2}$in) MDF, the overall dimensions of the cabinet are approximately 230mm wide × 330mm high × 120mm deep (8in × 13in × 5in).

The MDF panels are glued and pinned, and the cabinet finished with car spray paint. The tweeter unit is attached with cyanoacrylate adhesive (superglue) to the back of the speaker grille.

The speaker cutout must be extended beyond the foam suspension or the foam may clap against the case when heavy bass is being reproduced. Aperture diameter in the prototype cabinet is too small, and the speaker had to be held off the front panel by a ring of plywood.

Rear panel showing the four speaker vent holes. These holes also ensure adequate airflow to cool the transformer and heatsink.

When speakers are mounted in comparatively small enclosures, vent area in the back panel must approach the effective area of the speaker cone or the sound will seem muffled and "boxy". Four 75mm (3in) diameter holes are about right for the 205mm diameter speaker. This arrangement also ensures an adequate air flow to the mains transformer and the heatsink.

Aerial

Advantage should be taken of the cabinet's height and stability to install a long telescopic aerial. Aim for an extended length in excess of one metre (say 3ft 6in). The improvement in signal pick-up makes a difference with "weak" stations.

The case handle is formed by sandwiching 12mm × 3mm ($^{1}/_{2}$in × $^{1}/_{8}$in) steel strip between strips of wood, but a ready-made item would be equally suitable.

Performance

Sensitivity of the receiver is about the same as a conventional f.m. portable. If a commercial set performs adequately in the particular location, this simple design should also.

Bass response is impressive, despite the speaker's limited baffle area, and output more than adequate for domestic listening. The tweeter adds presence, and the overall sound quality is, in the author's opinion, exceptional by portable radio standards.

Some of the ingenious design features of the TDA7000 f.m. radio i.c. impose limits on the fidelity of the audio output, but this is not noticeable. The amplifier and speaker arrangements adopted for this rather potent receiver seem to make the most of its qualities rather than expose any weaknesses. □